

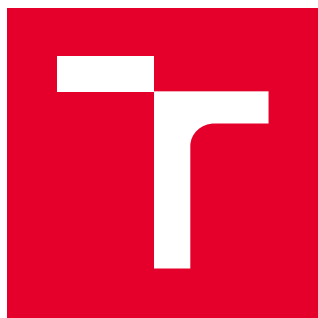
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THE LATEST TRENDS AND DEVELOPMENTS IN THE SMARTPHONE INDUSTRY

NEJNOVĚJŠÍ VÝVOJOVÉ TRENDY V OBLASTI SMARTPHONŮ

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ABSTRAKT

Hlavním cílem této bakalářské práce je vzít čtenáře do světa průmyslu v oblasti smartphonů, který má pozitivní i negativní dopad na lidi. Na začátku této práce je popsána historie mobilních technologií a vývoj generací mobilních telefonů. V další kapitole následuje popis nejvýznamnějších trendů současnosti a stručný nástin budoucích trendů. Následující kapitola je zaměřena na charakteristiku nejvýznamnějších značek smartphonů, jejich vzájemnou konkurenceschopnost a podíl na trhu. Poslední kapitola se zabývá porovnáním různých parametrů společnosti Apple a Samsung a pak bude poskytnuto závěrečné zhrnutí.

KLÍČOVÁ SLOVA

budoucí trendy smartphonů, historie mobilních technologií, nejvýznamnější trendy současnosti, podíl smartphonů na trhu, smartphone

ABSTRACT

The main aim of this bachelor's thesis is to take reader to the world of smartphone industry, which has even positive and negative effects on people. In the beginning of this thesis, history of mobile technology and evolution of the mobile phone generations is described. Subsequently a description of the most significant present trends and a brief outline of future trends follows. The next chapter is focused on the characteristic of the most significant smartphone brands, their mutual competitiveness and market share. The last chapter deals with comparison of various parameters of Apple and Samsung company, then a final summary is provided.

KEYWORDS

future smartphone trends, history of mobile technologies, market share of smartphones, smartphone, the most significant trends of the present

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V Brně dne

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Jakub Šteiniger

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CONTENTS

1 HISTORY OF SMARTPHONES.....	2
1.1 Mobile Network Generations 1G to 4G.....	3
2 SMARTPHONE TRENDS.....	7
2.1 Present smartphone trends.....	7
2.1.1 Artificial intelligence.....	7
2.1.2 Bezel-less display.....	7
2.1.3 The notch trend.....	8
2.1.4 Multiple cameras.....	8
2.1.5 Augmented reality.....	9
2.1.6 Holographic screen.....	9
2.1.7 More powerful hardware.....	9
2.1.8 Budget and feature phones.....	10
2.1.9 USB-C cables.....	11
2.1.10 Pixel 3 and Pixel 3 XL.....	12
2.2 Future smartphone trends.....	13
2.2.1 In-Display Fingerprint Readers.....	13
2.2.2 Foldable Phones.....	13
2.2.3 Pop-up cameras.....	13
2.2.4 Dual front cameras.....	13
2.2.5 The fifth generation(5G) technology.....	14
3 COMPETITIVENESS AND MARKET SHARE OF SMARTPHONES	15
3.1 Samsung.....	15
3.2 Apple.....	17

3.3 Huawei.....	19
3.4 Global Smartphone Market Share.....	21
3.4.1 U.S. Smartphone Market Share.....	22
4 COMPARISON OF PARAMETERS OF APPLE AND SAMSUNG.....	23
4.1 Operating systems: Android vs iOS.....	23
4.2 Samsung Galaxy S10/S10+ vs. iPhone XS/XS Max.....	26
CONCLUSION.....	30

LIST OF FIGURES

Figure 1.	Light L16 camera.....	8
Figure 2.	Global Smartphone Market Share.....	21
Figure 3.	U.S. Smartphone Market Share.....	22
Figure 4.	Geekbench 4.3.....	27
Figure 5.	Antutu Benchmark.....	27

INTRODUCTION

Smartphone is a mobile phone which offers functions and advanced technologies comparable with a personal computer. Smartphone is considered to be technological breakthrough that simplifies people's lives. In the past nobody would believe that smartphone would perform the function e.g. communication tool and would be able to text messages, send images, make video calls or as a source of entertainment to download applications or music from the internet. Many people in this world own a mobile phone that at least allows internet access. The old methods of sending and receiving messages physically are far back gone thanks to electronic messages (e-mails) located in smartphones. This technology shows its uniqueness every time when developers of famous brands come up with something new that can really help potential customers. Smartphone comes also with a software including calculator, radio, voice recorder, memo, calendar, music player, also GPS is a great advantage.

Due to smartphone technology people are able to be connected with their co-workers or friends and even things could be controlled more safely in a large distance if a situation requires it. It is widely believed that smartphones are a hot topic not only for its capabilities but also some rivalry or competition between the most well-known brands. I am personally very interested in smartphones and everything that is related to smartphones, so I decided to choose this topic for my thesis.

On the contrary, smartphones can be really distracting and addictive. For older generation it may take some time to become familiar with smartphones due to a more sophisticated technology and it does not have to be easy to learn how to use them.

For reader of this bachelor's thesis is important to know how the evolution of mobile smartphonees started. Therefore, the following chapter will deal with a history of smartphones and brief evolution of mobile network generations. The Second chapter describes the latest present trends of smartphones and revelation of future trends. The next chapter is focused on the characteristic of the most significant smartphone brands, their mutual competitiveness and market share. The last chapter deals with comparison of various parameters of Apple and Samsung company.

1 HISTORY OF SMARTPHONES

The term smartphone did not exist until the period when the first real smartphone was developed in 1992. The name of the smartphone was IBM Simon Personal Communicator. This type of smartphone had touchscreen to dial numbers, touchscreen could be operated by Personal Digital Assistant (PDA) element pen called stylus, which had ability to send and receive fax messages. Moreover, many applications like notepad, calendar, calculator, world time clock, email, address book were included in the mentioned smartphone.[1]

The phone was very heavy with cost of 900\$. This prototype was launched for sale in 1994, about 50,000 units were sold and lasted about 6 months on the market. Next notable effort for smartphone was in 1996 when the Nokia 9000 Communicator was introduced. Nokia managed to do everything the same as Simon could do, but Nokia contained better innovative applications including a graphical web browser. Atypical design resembled a clamshell and was able to hide a full physical QWERTY keyboard. It is widely known that this was a long time before Blackberry made popular physical keyboard on mobile phones. [2]

This period of time was considered to be the development of brand called Ericsson, but those prototypes such as GS88 were not successful and were discarded, moreover cancelled for a wide audience. However, in late 1999 the Ericsson R380 was launched and was able to be sold on market as a very first smartphone device. It was also a first mobile phone to use Symbian Operating System (OS) and contained Personal Digital Assistant (PDA) functionality. The indicated operating system managed to dominate the market until the 2010. [2]

Company Qualcomm is also considered to be important for its contribution to the history of smartphone. Qualcomm PDQ “smartphone” was introduced in June 1999. Qualcomm used integrated Palm PDA and internet connectivity. Treo 180, developed by Handspring company in 2002, is the first smartphone that used fully integrated Palm OS, where was SMS messaging and internet access built. [3]

Previously mentioned Qualcomm PDQ smartphone was also bulky and had to deal with some issues, but was still capable of launching. The next prototype called The Kyocera 6035 is first smartphone that was tied to Verizon company in 2001 and used separated

Palm Operating system, which was released in early 1996.[2]

Microsoft began to work on prototypes of smartphones in 1990, but company did not see a clear future with them, so the company started with porting a Windows into mobile devices. [2] Subsequently, Windows Mobile was fully developed in 2003.

New breakthrough came in 2007 when the smartphone era changed completely with introducing iPhone by Apple that can be seen on market constantly. It denoted the beginning of the rise in demand for mobile phones and challenged everything created before iPhone. However, due to lack of ability to have third-party applications installed, the entire iPhone platform had to be closed. Six months later, the ability to add these applications was introduced. In 2008 HTC signed up and introduced HTC Dream, the first android device. Later on, other manufacturers such as Motorola, Samsung, LG started to pay much more attention to Android OS.[1]

Android and iPhone devices made smartphones popular due to large-sized touchscreen. Microsoft ended up with Windows Mobile and started another touchscreen-oriented OS, called Windows Phone. Windows Phone was adopting totally different attitude to its interface with purpose to be different from iOS (iPhone Operating System). Nokia ended up cooperation with Symbian OS and made partnership with Microsoft, because of using Windows Phone on their smartphones. As a result of these events, Windows Phone turned out to be the third most popular OS, before being taken over by its successor Windows 10 Mobile.[3] The first cooperation of Nokia and Microsoft was successful with production of device Nokia Lumia 800.

1.1 Mobile Network Generations 1G to 4G

The first-generation mobile communication first appeared in 1980s, which was based on analog system. Analog signals sent transmission from the phones to radio towers. The most popular analog first-generation systems were advanced mobile phone system (AMPS) which was launched in United States. Nordic mobile telephone (NMT), total access communication system (TACS) and some other systems were also introduced in 1980s across the Europe. All of the standards in the first generation used frequency modulation techniques for voice signals. Analog systems were based on circuit switching technology and offered only voice communication, no data communication. [4]

In 1983, the first mobile phone became available through Motorola. Voice calling was its only functionality. Due to weigh of 2 pounds was Motorola known as” the brick” and was also expensive with a price of 400 dollars and provided an hour of talk time before its battery would run out (Ciaramitaro, 2011).

The first generation has some of the disadvantages regarding overall connection quality, poor voice links, unreliable handoff, and low security because voice calls were played back in radio towers, making these calls predisposed to unwanted interference by foreigners. [5]

The second generation mobile communication was introduced in 1991 in Finland and preferred a transmission of digital signal rather than the analog signal used in previous generation. Digital signal provided better quality for voice communications and improved system capacity and network coverage. 2G technologies provided several mobile phone networks with services such as text messages, MMS (multimedia messages). The first text message was sent in England in 1992. By 1994 users worldwide were only sending about 4 text messages per month (Ciaramitaro, 2011).

2G technology is more efficient due to its enhanced security for both the sender and the receiver. All text messages are digitally encrypted which enable transfer of data in a way that text messages can be received and read only by an intended recipient. [6]

The most well-known wireless technology is called Global Systems for Mobile Communications (GSM). GSM technology was the first to establish international roaming in approximately 140 countries. Mobile subscribers were allowed to use their mobile phone connections in many different countries of the world based on digital signals. GSM uses Time Division Multiple Access (TDMA) that allows the division of signal into time slots and Code Division Multiple Access (CDMA) is able to receive signals on a single communication channel from multiple transmitters simultaneously and afterwards is able to distinguish individual signals from each other. [4]

The next generation of mobile networks is referred to be the bridge between the second and third generation technologies, which was introduced between the years 2000-2005. 2,5G network provided services including voice communication and data communication due to circuit switching domain and packet-switching domain.

The added functionalities such as phone, text, calendar, calculator, fax and email available in the 2.5G network were beneficial to users what led to increase of adoption of mobile devices and by 2002 the number of mobile users was 1 billion (Ciaramitaro, 2011).

The third generation of mobile networks first appeared in 2001 in Japan, but these mobile networks were fully adopted in 2005 (Ciaramitaro, 2011). 3G fulfils the requirements of the International Telecommunication Union (ITU) which came up with a plan known as (International Mobile Telephone, IMT-2000) to carry out a global frequency band in the range of 2000 Mhz. Moreover, to meet these standards a system is required to provide peak data rates. [4]

The most useful IMT-2000 solution is The Universal Mobile Telecommunications System (UMTS) used in Europe. The most well-known UMTS air interface is called Wideband Code Division Multiple Access (W-CDMA) successor to GSM used in 2G. WCDM provides advantages of high transfer data rate and also due to 3G technologies enables network operators to offer users more advanced and improved services because of greater network capacity and more improved spectral efficiency. On the grounds of faster data rates up to 2Mbps, which gave networks the ability to support multimedia applications such as video calling, file transmission, GPS (global positioning system) mobile internet access, mobile television and global roaming. [4]

3G era was significant with adding of the web browser. Introduction of web browser signified the demand for mobile phones, so that the information from the internet can be searched for any user and accessed on demand. (Ciaramitaro, 2011)

The fourth generation (4G) mobile communication can be described with an expression as a “speed generation”. Long Term Evolution (LTE) is considered to be the 4G technology and evolution of UMTS from the third evolution. 4G provides faster download speed up to 100Mbps and upload speed up to 50Mbps, in comparison to the third generation, the difference is considerable. [4]

The fourth-generation system enables to provide a 100 % IP based broadband network to devices like smartphones, computers, laptops or wireless modems etc. Furthermore, the network enables to use high demand applications such as streamed multimedia, gaming, Voice over Internet Protocol. 4G networks are made to meet quality of service requirements in which are able to prioritize the various types of data traffic for the most optimal results. Importantly, high bandwidth capabilities are supported and offered through

the fourth-generation network including: High Definition Television, Digital Video Broadcasting, Wireless Broadband Internet Access, Multimedia Messaging Service, Real Time Audio, High Speed Data Transfer. (Ciaramitaro, 2011)

2 SMARTPHONE TRENDS

2.1 Present smartphone trends

Smartphone industry is improving every year and brings enhanced innovations for its customers. Mobile World Congress is considered to be the world's largest exhibition for mobile industry, which takes place in Barcelona and based on the several announcements, the trade show already explained, which innovations and products should be expected. During the year 2018 and in the first half of 2019, the most dominant brands offer new products such as Samsung Galaxy S10, S10+ or Huawei Mate 20 Pro or iPhone XS, Huawei P30 Pro. From more powerful processors, facial scanning, multi-camera smartphones to artificial intelligence, there are still many other trends to talk about and in this chapter, the present smartphone trends will be discussed in a more detailed way.

2.1.1 Artificial intelligence

The first significant trend is Artificial Intelligence. In 2018, LG made an announcement at Mobile World Congress with an introducing a of LG V30S version packed with artificial intelligence. LG's AI improvements include camera application specifically, where it can distinguish scenes and use the right colours for making a photo. [7] Artificial intelligence is getting more predominant and complicated. Specialized chips are required to fulfil AI tasks and this is undoubtedly one of the most interesting trends. Companies such as Huawei and Apple make their chipsets in their phones with specialized AI chip, also Google company is using specialized AI chip for their camera. Localised AI chip will not only provide faster smartphones but also better privacy, because individual computations and analysis of data will be done directly on the phone.[8]

2.1.2 Bezel-less display

Bezel-less display is another actual trend to discuss on smartphones. Xiaomi Mi Mix started this trend in 2016 and bezel-less displays caught attention of another smartphone companies, which received positive responses, even Apple embraced this idea. Smaller and more narrow phones got advantage of gaining more screen space. For comparison, iPhone X is smaller than iPhone 8 Plus, however iPhone X has bigger screen and more narrow smartphones have possibility of adopting the 18:9 aspect ratio over 16:9. The advantage of 18:9 aspect ratio is much more space for split-screen mode allowing

multitasking and even more content to see in vertical scrolling applications. [7]

With bezel-less smartphone and the adoption of fingerprint, home button is about to disappear out of sight.

2.1.3 The notch trend

There is another display trend that is interesting, the notch. iPhone X has notch that looks like cut-out into top of the screen. The notch includes the TrueDepth cameras and sensors which provide face recognition and application of animal faces (Animoji's). Many phone manufacturers decided to copy this not well-received Apple feature and smartphone companies added notches to their phones such as the Asus ZenFone 5, Huawei P20, P20 Pro or even LG G7. Except for Samsung, which decided for using a black stripe instead of notch. However, these notches are not more valuable than the function of front-facing camera. [7]

2.1.4 Multiple cameras

There is no doubt that in the past two years, dual cameras and quad cameras (two on the front and the back) were known. However, in 2018 Huawei has introduced the first device having three cameras at the back called Huawei P20 PRO. Every camera has different function. The first one captures in colour RGB, the second one captures in monochrome (means unicolor: black-and-white) and the third one zooms into an object.[8] Nevertheless, this is just a beginning, because nowadays even better P30 PRO has tripple rear cameras plus time of flight sensor. Interesting can be innovation of smartphone sized camera by American digital photography company, which came with the prototype Light L16(see fig. 1), which does not consist of three, or four cameras, but nine cameras with 16 lenses of varying focal lengths to capture particular high-resolution images also offers large zoom capacity of 28 millimeters to 150 millimeters. [9] [10]



Figure 1. Light L16 camera. Retrieved October 16,2018 from <http://www.adventurealan.com/light-l16computational-camera-hands-on-first-look/>

2.1.5 Augmented reality

Augmented Reality was another interesting announcement at Mobile World Congress. AR is amazing for gaming, in 2016 Game Pokemon Go has already proved that well realized AR can attract attention of crowd. [9] After unsuccessful early effort of Google to bring augmented reality to phones with so-called Project Tango, Google found replacement, known as ARCore. It is supported in several phones such as Google Pixel 2, Google Pixel 3 and Samsung Galaxy S9 or S9 Plus. [11]

Google lens is well known AR application developed by Google. It 's an AR and AI platform built into Google Assistant used for object recognition, image recognition or has an ability to create virtual 3D images, AR can be used also for better maps navigation, online shopping, for education.

2.1.6 Holographic screen

There has been many discussions and uncertainties about Holographic screen. However, Red Hydrogen One is the first smartphone containing a feature called Holographic screen with cost of 1300 \$ in pre-order. Cooperation of Red Company well known for its cinematic cameras and Leia Inc that is Silicon Valley company dealing with light-field displays for mobile devices has resulted in development of Holographic screen. [9] The function of this screen is to project 3D objects, which are visible from different angles depending on a position of person.

2.1.7 More powerful hardware

Smartphones are being are very powerful, almost more powerful than computers. Therefore, more powerful hardware is needed. Qualcomm Snapdragon 845, one of the fastest android processors and one of the best android smartphones contain Snapdragon 845, such as Samsung Galaxy S9, S9+, Sony Xperia XZ2 Premium, Samsung Galaxy Note 9, Xiaomi Mi 8, LG G7 ThinQ are powered by this processor. [8] It manages to capture 4K Ultra HD videos at 60 FPS (frames per second) and 720p videos at 480fps. This processor also supports integrated Adreno 630 GPU (graphic processing unit), alongside with Kryo 385 CPU (central processing unit) and support for Qualcomm Quick Charge 4, 4+ technology for rapid charging. [12],[13]

Expectantly, newer versions Samsung Galaxy S10, 10+, S10E and S10 5G feature the newest Snapdragon 855.

2.1.8 Budget and feature phones

In the past low-priced phones were warning for potential customers due to its slow performance, poor quality of camera. However, budgets phones and feature phones are getting better and the year 2018 offered low-prices mobile phones that are worth to buy.

Motorola Moto G6 is very reliable smartphone which provides several solid attributes. This low budget phone is available for approximately 260€. The phone offers bright and clear Full HD 5,7-inch display, Android 8, 4GB RAM and storage 32 or 64 GB. The back design of the phone is made from 3G glass with rounded edges. On the bottom part of the phone is placed USB-C slot and fingerprint sensor on the front of the phone. Moto E5 Plus can be described as a top budget phone that can be bought on the market. With the price 200€ it has a big screen, long lasting battery 5000mAh(milli-Ampere-hours) with 12 MP rear camera and operating system Android 8.0 even storage 32 GB. [14]

Motorola 's Moto G5 is considered to be one of the best budget phones in the world. This phone can be bought under 200€ and Moto G5 provides metal design with features like fingerprint scanner and 1080p display. It has not the fastest chipset Snapdragon 430, nevertheless technical issues should not be expected and with the price Moto G5 offers, it is bargain price.

Samsung 's top low-priced phone is Samsung Galaxy A8 which is available under 300€. The main advantage is its top-class front and back camera, Super AMOLED screen with 4GB RAM and eight-core processor. Alcatel 3V Spectrum is considered to be one of the cheapest reliable smartphones on the market. For spending approximately 140€, potential customer can expect set of impressive features such as six inch +18:9 screen and with 2K resolution, a dual rear camera system and fingerprint scanner or function of unlocking a phone with Face Key technology. The Alcatel 3V also comes with Android 8.0 Oreo. [15]

Motorola's Moto G7 series are also quite impressive low budget smartphones. These models contain quite impressive attributes. The first to mention is Moto G7 Power. If user cares about the long-lasting battery life with a good price, this is the right phone to buy. It has 5000mAh large battery available with price under 200€. It contains the latest Android 9 and quite large 6,2-inch display. The second model Moto G7 Play contains average 3000mAh, but better 13MP rear camera and 8MP front camera. The third and last type to mention is Moto G7 Plus, which has also 6,2-inch display and impressive dual rear camera containing 16 MP main camera, 5MP depth sensor, 12MP front selfie camera

and ability to record 4K video as the other G7 series models.

Sony Xperia XA1 is probably the best low-priced smartphone with amazing 23MP camera. It is unlike to buy a phone with a better camera just for 150€. For this price it also offers 3GB of RAM and 720p display, but negligible drawback of this smartphone is not that long-lasting battery life. Huawei 's sub-brand Honor offers Honor 8X only available for 230€. Great advantage is large 6.5-inch screen and 19.5:9 aspect ratio screen. The phone has glass back and metal frame. Kirin 710 is not the most powerful but it offers 64 or 128 GB storage, with a solid camera, and has 3750mAh battery. Honor Play offers incredible features and is definitely one of the best budget Android smartphones on the market. For a price 320€ Honor Play offers fast Kirin 970 CPU, 4GB of RAM and large 6,3-inch Full HD+ screen and 64 GB of internal storage space, moreover awesome performance for games. [15]

2.1.9 USB-C cables

USB Type-C is the newest type of Universal Serial Bus (USB) connector used for charging and also for data transfer. The adoption of USB-C cables is a shift for the better future for smartphones. This type of connector has been here since 2015, but the year 2018 showed it's take over on smartphones. In the past people witnessed plug-in failures due to wrong direction of the cable. The difference lies in reversible connector meaning that cable can be plugged in whichever way without being afraid of damaging the port. [16]

For instance, Android smartphones such as Google 's Pixel 3 XL, Samsung Galaxy S9 Plus or LG V40 ThinQ contain the USB-C port. The Type-C is universal because it supports all the three standards USB 2.0 capable of 480Mbps, USB 3.0 capable of 5Gbps and USB 3.1 capable of 10Gbps. The next aim will be concentration and recommendation on the best USB-C cables of 2018. [17]

Anker Powerline USB-C to USB 3.0 is almost one meter long cable which has great resistance, durability and potential customers can rely on it. The cable has double braided exterior and strong fiber core. The possibility of bending the cable is reduced due to reinforced necks whose aim is to prevent cable damage. Data can be synchronized up to 5Gbps, however quick charging is limited to 2,4A. The price is around 10€ and lifetime warranty is guaranteed. Google USB-C to USB-C cable is not limited with quick charging and offers up to 60 W at 3 A. Charging speed depends on the device or charger but this

cable supports USB 3.1 for transmission of data up to 10 Gbps. The price of Google USB-C to USB-C cable is around 18€ and is 1,8 meters long with warranty for about 12 months. Tronsmart USB-C to USB-A cable offers three different packs on the basis of the cable length (0,3m, 1m, 1,8m). This cable manages to handle speed up to 5Gbps and is really durable with gilded connectors. Quick charge is guaranteed with warranty for 18 months. iOrange-E USB-A to USB-C is reversible braided cable made from nylon material is so strong that there is no possibility for the cable to be tangled. The cable also supports fast charging which supports phones such as Samsung Galaxy S8, LG Nexus 5x, OnePlus 5 or Lumia 950. Interesting feature is LED placed in the connector. When the connector lights up with red colour, the device is charging, or blue for fast charging and finally it changes to green colour, which means that the device is fully charged. The price of this cable is 10 € and is almost two meters long with 12 months warranty. [17]

Nekteck USB Type C Cable is compatible with all smartphones which have USB Type-C connector. This cable also supports quick charge. Nylon material helps to prevent the cable from knotting and also due to aluminium shielding. The length of this cable is 1 meter and warranty is 18 months. [17]

2.1.10 Pixel 3 and Pixel 3 XL

The Google Pixel 3 and 3XL are considered to be the best camera phones. The Pixel 3 and Pixel 3 XL have the same camera setup. The rear camera has 12,2 MP and front camera has 8MP+8MP. These powerful cameras provide more sharper and brighter photos than Samsung Galaxy Note 9 and iPhone XS Max, Huawei P20 PRO. The main reason why these Google phones are considered to have the best cameras is because Huawei P20 PRO has frequently over-sharpened photos, iPhone XS Max tends to pull colours into the warm tones and Samsung Galaxy Note 9 has not always high dynamic range photos. Both google smartphones have dual front facing cameras offering to take selfie in a portrait mode with a blurred background. For comparison, Pixel 3 XL has a bigger display size and resolution than Pixel 3. The both phones have Android 9 Pie and video capture 4K, processor snapdragon 845, storage from 64 GB to 128 GB. The difference also lies in longer battery life of Google Pixel 3 XL (3430mAh) while Google Pixel 3 has 2915mAh. [18],[19]

2.2 Future smartphone trends

2.2.1 In-Display Fingerprint Readers

This trend is not considered to be the new one, but in 2019 in-display fingerprint readers should be seen regularly. The name implies, the fingerprint reader is placed inside the display of the phone and there is no necessity to look for this function behind or at the bottom part of the screen. Simple tapping on the screen unlocks the phone. This idea provides more screen space because the regular fingerprint reader will not be added to the bottom of the phone. Announcements of all flagship phones such as Samsung Galaxy S10, Huawei Mate 20 PRO are going to feature the in-display fingerprint reader. [20],[21]

2.2.2 Foldable Phones

Foldable phones are considered to be another innovation that may be seen in 2019 more often. Foldable display should help to prevent the possibilities of breaking the smartphone. The most well know companies such as Samsung, Huawei, Xiaomi and Oppo already announced that they will feature function of foldable smartphone. Samsung Galaxy X is the first smartphone with possibility of foldable display. The idea of Samsung is that phone folds in the middle and fully cover one side. Huawei 's plans are similar to Samsung, but with the different hinge in the middle. Oppo come up with the concept of "Book" Design. The design may remind of ZTE Axon M, but Oppo will offer much better display. The noticeable downside of ZTE Axon M is the gap in the middle of the screen, which looks like two phones are glued together. [20],[21]

2.2.3 Pop-up cameras

This innovation exists thanks to Vivo company and their first ever prototype with pop-up camera module Vivo Apex. The process is only to turn on front camera and the camera pops-up from the top of the smartphone. Later on, Oppo company with phones Oppo Find X even improved this innovation by adding a rear camera and the other sensors for 3D face recognition. Vivo Nex has a pop- up selfie camera and Xiaomi and Lenovo also announced similar pop-up cameras for Mi Mix 3, Lenovo Z5 Pro. The trend with pop-up cameras will go mainstream and there will be much more to see in 2019. [20]

2.2.4 Dual front cameras

The year 2018 was significant for the dual rear cameras and the year 2019 will belong to

dual front cameras. Dual front camera trend originally started by Honor and subsequently Google with Xiaomi designed these cameras for their Google Pixel 3XL, Xiaomi Redmi Note 6 Pro. There is no doubt that other smartphone brands will introduce their devices including dual front cameras and bokeh mode capability or in other words blurred background effect is expected not only for the rear camera but also for the front dual camera. [22]

2.2.5 The fifth generation (5G) technology

The latest 5G technology will be the next trend, which can help to improve smartphone qualities, mostly to increase speed. All the smartphones compatible with 5G will use Qualcomm Snapdragon X50 5G that allows 5x faster download speed (up to 5Gbps) than the predecessor 4G. Another smartphone conveniences, which are expected with a 5G technology are: better video quality, 360-degree video streaming. [23]

The most well-known smartphone companies such as Samsung, Huawei, OnePlus, Sony are launching their 5G smartphones in 2019. Samsung Galaxy S10, made by Qualcomm and South Korean makers, was launched in February at Mobile World Congress 2019 with capability of 5G connectivity. Chinese smartphone manufacturer, known to have favour for high speed smartphones with great performance, announced that OnePlus 7 is another smartphone that will feature the 5G technology. Sony likewise launches a smartphone and according to the Sony Mobile team, Sony Xperia 5G is about to be the first 5G smartphone with a capability of a battery that can last an entire week. Release date of Sony Xperia 5G is similar to rival company Samsung, before the end of February 2019. [24]

Company Huawei introduced smartphone called Huawei Mate X, which is foldable and contains 5G technology along with Kirin 980 processor. There is a probability that future Huawei Mate 30 will also contain 5G technology. However, P30 Pro released in March 2019 does not contain 5G technology.

3 COMPETITIVENESS AND MARKET SHARE OF SMARTPHONES

The smartphone market is crucial for all significant smartphone manufacturers and is described like a war, because predominant companies are fighting for the better position on the global market. Global smartphone market share compares statistics and rivalry between American company Apple, Chinese company Huawei and undoubtedly South Korean company Samsung. Firstly, these various companies will be described and subsequently their statistics on market share will be compared.

3.1 Samsung

As previously mentioned, Samsung is a company from South Korea which is considered to be one of the largest producers in the world, concerning electronics devices. Specifically, it includes digital media devices, memory chips, integrated systems, various appliances, but the most importantly Samsung has made one of the biggest impacts on technology, meaning that Samsung provides about 20% of total South Korea's exports. [25]

Samsung was established on the first of March, 1938 by successful South Korean businessman Lee Byung-Chull. Following years of Samsung were connected to textile industry, which ended up in creation of small companies. Officially in 1969 Samsung started business with electronics focused on televisions. After its success, televisions started to be exported abroad. The years around 1980 were successful for Samsung because of its technological expansion in company, in terms of semiconductor production, establishment of aerospace division. Samsung set up two institutes with attention to telecommunications, nanotechnology, aerospace, electronics.[25]

Later in 1990s Samsung was affected by scandals referring to patent-infringement suits and bribery. Despite this unpleasant period, Samsung still managed to produce high-quality products such as computer monitors or LCD screens. This production helped company with reaching the upper positions in global market share. Since 2006, Samsung has been the leader in manufacturing of televisions. [25]

The next significant chapter for Samsung started when Samsung Galaxy series were created. Samsung Galaxy S series started the whole process in 2010 and this was the moment when Samsung started to be significant smartphone manufacturer and the opponent to Apple, which had already begun their iPhone series.

Samsung Galaxy S was introduced in June 2010 with Android 2.1 and 1GHz processor, 500MB of RAM. The other added features were Super AMOLED display 800x480 and 5MP rear camera and only 0.3MP front facing camera. As the years went by, every year new Samsung Galaxy of S series was introduced with better and better attributes. Samsung Galaxy S3 was introduced significantly with respect to first smartphone in the S series to include HD screen with resolution 1280x720 and Android 4.0. The rear camera was 8MP, the same as in Samsung Galaxy S2. Samsung Galaxy S4 had a 13MP rear camera and Galaxy S5 even more with 16MP. In April 2015, Samsung introduced two separate devices simultaneously, Samsung Galaxy S6 alongside with S6 Edge. [26]

The same process happened in February 2016 when Galaxy S7 and S7 Edge were introduced. In April 2017 Samsung Galaxy S8 and S8+ offered Infinity Display, which is virtually bezel-less display, also home button was moved to back side of smartphone. In March 2018, the last launched phones were Samsung Galaxy S9, which have ability to create 3D emoji avatar and S9+ with ability of dual aperture main camera. New Samsung Galaxy S10, S10+ and S10e were introduced recently. [26]

Galaxy S10 has 8GB of RAM and 128 or 512 version of storage availability, with 6.1-inch AMOLED display and 3400mAh battery. Galaxy S 10 models use Android 9 Pie. Both S10 and S10+ feature in-screen fingerprint scanner, also these smartphones have three rear cameras, which includes 12MP telephoto and wide-angle lens, but 16MP ultra-wide camera was added with 123-degree field of view. Interesting feature is reverse charging that means to use a phone as a replacement for powerbank to charge another device. Galaxy S10 Plus features 1TB storage capacity and 12 GB RAM, with 4100mAh battery and 6.4 Super AMOLED display. Also, Samsung Galaxy Fold was introduced with availability to open like a book with a large 7.3-inch screen. [27],[28], [29]

Interesting to mention may be Note Series, which are using stylus pen. The first model Samsung Galaxy Note was introduced in 2011 with 5,3-inch display and 8MP rear camera. One year later, Galaxy Note 2 offered slightly better specifications including

3100mAh battery, quad-core processor. Finally, in 2013, there was a progress with 13MP rear camera, which occurred in Galaxy Note 3. Galaxy Note 4 was interesting for its metal frame design and 16MP rear camera along with fast-charging attribute. In 2015, Galaxy Note 5 offered a redesigned stylus pen with screen off memo feature, which allowed possibility of writing down notes or ideas wherever is needed. Curiosity happened in 2016 when Samsung decided to continue with Galaxy Note 7 not 6 because they wanted to have the same numbering with S and Note series. Galaxy Note 7 was introduced with intelligent security called iris recognition and ability to be water resistant, also the first Note of series to support HDR (High Dynamic Range) video. Samsung Galaxy Note 8 featured dual rear camera, infinity display with 18:5:8 aspect ratio and finally the latest Galaxy Note 9 was released in August 2018 includes 4000mAh battery with new stylus pen that is capable of wireless charging and bluetooth connectivity, intelligent camera: scene optimizer and large display with 6,4 inches. [30]

3.2 Apple

Apple is American company located in California. Company was established in 1976 by Steve Jobs, Steve Wozniak and Ronald Wayne with specialization on hardware and software. Apple hardware products consist of the smartphone called iPhone, but also a computer called Mac, tablet called iPad or other electronics such as Apple Watch. Second part is operating system that can be found in MacOS or in smartphones iOS. Apple is known also for its iTunes media player for music or Safari browser, online stores such as iTunes Store, Apple Store, the iOS and Mac App Store. [31]

First memorable launch that had considerable impact on a tech market takes place in January 2007 when Steve Jobs released the first ever iPhone to the world. Steve Jobs described iPhone as a mobile phone, internet communicator and wide touchscreen iPod in one device. It meant decline for brands like Blackberry or Nokia. After the launch in 2007, more than 1 billion iPhones were sold worldwide and iPhone is also considered to have three of the five smartphones that were ever sold in the world. [32]

The leader is iPhone6 and iPhone 6 Plus with 220 million sales, iPhone 7, iPhone 7 Plus with 78 million sales, iPhone 5 with 70 million sales. The top five includes Samsung Galaxy S4 with 80 million sales and Nokia 5230 with 150 million sales. [33]

The first iPhone offered only 2MP camera with 4GB storage model started at 500\$, 8GB

for 600\$. These prices brought criticism because they were too expensive. 16 GB model version was introduced later for this model. In 2008, iPhone 3G, which was similar to original one, but first one to offer GPS and in 2009 iPhone 3GS offered 32 GB storage version for 300\$ with 3MP camera. [34]

iPhone 4 contained front-facing camera and 5MP rear camera. In 2011 iPhone 4S launched popular smart voice assistant Siri, 8MP camera with 1080p video recording and also 64 GB storage was introduced. In 2012, iPhone 5 was the first device with support of 4G LTE and about 5 million models of this iPhone were sold for the first week. In terms of colours, better balance for RGB (red, green, blue) standard was provided. In 2013, it was the first time when two models, iPhone 5S and 5C were released at the same time. iPhone 5S featured innovation in terms of 64-bit chip call Apple A7, also security system for identification so called Touch ID and recording of slow-motion video. [35],[36]

After the development of previous models of iPhone, manufacturers were thinking about the decisions or innovations, which would make the upcoming models better, interesting and surely more persuasive for the customers. This also meant a technological breakthrough within the iPhone company and an effort was worth it.

In 2014, Apple finally launched models with bigger screen. Moreover, models iPhone 6 with 4.7-inch display and 6 Plus containing 5.5-inch display, were introduced simultaneously. These models brought a competition to the rival company Samsung with their Galaxy S and Note series. Besides, new processor Apple A8 appeared in these two iPhones along with better camera and faster auto-focus. There was no need to worry about storage because it offered 128 GB option.[35]

As far as display is concerned, there was no difference in iPhone 6S and 6S Plus, but finally change in camera to 12MP with ability of 4k video. These models got fast Apple A9 processor and new technology called 3D touch was introduced. In 2016 Apple introduced iPhone 7 and 7 Plus model, which looked like their predecessors, but without audio jack that was removed, storage could go up to 256 GB. Both iPhones used quad-core Apple A10 Fusion processor.[34] Version 7 Plus contained dual rear camera system with a portrait mode with ability to zoom in photos and blurred background.

In 2017 three models were launched by Apple. iPhone 8 and 8 Plus caught attention for its aluminium design and retina display. Improved A11 Fusion processor with six cores

is much faster than its predecessor. With two performative cores and four efficiency cores it makes 25% and 70% difference in speed. New features were added including new colour filter, faster sensor 4k video up to 60fps. These iPhones support wireless charging. [34]

The third prototype is called iPhone X which was introduced in the end of 2017. Its actual price of 64GB storage version is about \$999 and for \$1,149 for 256GB. Despite the price, iPhone X has many new features such as better Apple A11 Bionic processor, dual cameras, Face ID, Super Retina display or in other words edge-to-edge screen. In late 2018, iPhone XS, XS Max and iPhone XR were announced. These iPhones have the newest A12 Bionic processor in common. The biggest display featured in XS Max with 6,5-inch. The iPhones XS, XS Max have the biggest battery, with comparison to iPhone X there is hour and half more battery life. There is possibility of storage capacity from 64 GB up to 512 GB. The iPhone XR features 6,1-inch Liquid Retina Display. [34],[36]

3.3 Huawei

Huawei is private Chinese Company established in 1987. After the establishment Huawei focused on production of phone switches. Company created a research centre and started to do business called Research and Development (R&D). In 1997, company managed to gain their first international project. Two years later Huawei established its first Research and Development (R&D) centre in India. The main aim of the company was to make a breakthrough in international markets. Huawei is the first company to provide Long Term Evolution (LTE) mobile services with Evolved Packet Core (EPC) technology to telephone company Telia Sonera in Norway in 2009. In following years, Huawei focused more on expansion in mobile technology and production networking products. Successful breakthrough brought cooperations with well-known companies such as Bell Canada, T-mobile, Motorola, Vodafone, TalkTalk. Huawei specializes in three key business sectors including manufacturing of communication devices, Enterprise Business and Telecom Carrier Networks. There are many technologies made and offered by Huawei such as soft switches, embedded modules, USB modems, wireless gateways, also Huawei tablets, Smartwatch and cell phones. Huawei is considered to be the largest telecommunications equipment maker in the world. Moreover, Huawei the leader in production of soft switches, which serve for implementation of Voice over Internet Protocol (VoIP) technology. [37]

Referring to phones of Huawei, in 2013 Huawei launched very popular Mate series with Huawei Ascend Mate. In 2016, Huawei started to gain attention from public because of an interesting launch of three devices in one year, Huawei Mate 9, Lite and Pro. Next year in 2017 Mate 10 series were introduced. This period was the time when leading smartphone brands Samsung and Apple started to consider Huawei as a serious opponent, because in 2018 Huawei introduced Mate 20 series including Mate 20, Mate 20 Pro, Mate 20 Lite and Mate 20 X. Huawei Mate 20 Pro is considered to be one of the best phones on the market.

This model is water, dust resistant and with comparison to Mate 20 containing 4000mAh battery has bigger 4200mAh battery with wireless charging. On the other hand, Mate 20 has 6,5-inch display, which is bigger from Mate 20 Pro only for 0,1-inch. Mate 20 Pro and Mate 20 also share some similarities such as the same Kirin 980 processor, 128 GB of storage, Android 9 Pie and 24MP front-facing camera. Both also have three rear cameras but Mate 20 Pro features better specifications of rear cameras. Huawei Mate 20 X has 6GB of RAM and is much bigger with 7.2-inch screen with Full HD+ resolution. This large device includes 5000mAh battery, which has about 30% more battery life with comparison to Mate 20 Pro. [38],[39]

Along with Huawei Mate series, also Huawei P series are very popular. These series started to gain attention similarly like Mate series in 2016 with launching of Huawei P9. In Huawei's top 10 2019 smartphone list can be found except for Mate series also Huawei P30 Pro, P30, Huawei P20, P20 Pro, P10 Plus and P10, Huawei P Smart 2019 version, which feature e.g. 6.2-inch display, Android 9 Pie, 3400mAh capacity of battery.

3.4 Market Share

Global Smartphone Shipments Market Share (%)	2017Q4	2018Q1	2018Q2	2018Q3	2018Q4
Samsung	18%	22%	20%	19%	18%
Apple	18%	14%	11%	12%	17%
Huawei	10%	11%	15%	14%	15%
Oppo	7%	7%	8%	9%	8%
Xiaomi	7%	8%	9%	9%	7%

Figure 2. Global Smartphone Market Share. Retrieved February 12, 2019 from <https://www.counterpointresearch.com/global-smartphone-share/>

The following table shows the statistics of the most significant smartphone brands for the last quarter of the year 2017 and the whole year 2018. The statistics deal with the shipment volume of individual companies and their percentage increases and decreases.

In the past years Samsung proved that according to worldwide range they are the leaders on global market share, despite the decline in shipments in the end of 2017 and evened up by Apple. However, The South Korean Company Samsung managed to maintain the first place during the year 2018 mostly due to flagship Samsung Galaxy S9/S9 + and also with help of Galaxy J series. Their shipment volume for 2018 was almost 300 million units and without any doubts, there is no other phone manufacturer, which would reach this number.

Huawei was able to get to the second position, when this company managed to surpass Apple in the second quarter of 2018, the strong impact was made by Huawei P20 and Huawei P20 PRO series where these smartphones managed to build high profile in the global market. However, Huawei was marked by the successful increase of Apple during the last quarter, therefore Huawei remained in the third place, the same as in the beginning of 2018. Shipment volume of Huawei went rapidly up for about 50 million units with comparison to the year before.

Apple had very good end of 2017 and start of 2018, but after fluctuating middle part of 2018, they dropped to third spot. However, in the end of the year 2018 new launched models iPhone Xs and iPhone Xs Max help to increase statistics on market share and raise

shipments, which meant Apple got the second place. Despite this attempt, their shipment volume statistics did not increase with comparison to the year 2017, thus their expectations have not been met.

Xiaomi did not manage to keep up with top three smartphones companies and remained narrowly on its fourth position until the third quarter 2018, when in the last quarter OPPO had overcome Xiaomi only for 1%. During the period of 2018, few models such as Xiaomi Redmi 5A, 6A and Xiaomi Redmi Note 5/5Pro helped to raise market share with comparison to the previous year. Their shipment volume for 2018 was raised considerable for about 30 million units

As previously mentioned OPPO stayed at the fifth place according to global market share 2018, despite the attempt during the last quarter.

3.4.1 U.S. Smartphone Market Share

US Smartphone Shipments Market Share (%)	2017Q4	2018Q1	2018Q2	2018Q3	2018Q4
Apple	44%	37%	40%	39%	47%
Samsung	19%	26%	25%	25%	22%
LG	14%	14%	16%	17%	12%
Motorola	5%	4%	5%	8%	6%
Other	18%	19%	14%	11%	13%

Figure 3. US Smartphone Market Share. Retrieved March 3, 2019 from

<https://www.counterpointresearch.com/us-market-smartphone-share/>

Apple started 2018 as a leader in U.S. market with 38% share. Apple had a decent start also because of launching the iPhone X. ZTE company had 11% share in the first quarter of 2018 but in second quarter ZTE company had to face sanctions from US government so US smartphone market noticed 22% decline. Motorola managed to slightly increase their statistics according to year-over-year comparison, mostly in third quarter. In the end of 2018 Apple had the best statistics with shipment, production due to iPhone XS, XS Max and XR models. Next positions were filled by Samsung, LG and Motorola. [40]

4 COMPARISON OF PARAMETERS OF APPLE AND SAMSUNG

4.1 Operating systems: Android vs iOS

Nowadays, there is a very high probability that people have a great chance to buy a smartphone, which will run on Android or iOS. Android and iOS were involved in almost 100% of all smartphones shipped in 2018. Both smartphone operating systems have something in common, but they are also different in various features. The very first important feature is price affordability. On the grounds of price, Android offers smartphones such as Galaxy Note series or Samsung Galaxy S10+, which are equal to Apple's iPhone prices such as the latest iPhone XS Max. However, there is a large amount of low-cost affordable Android smartphones from different manufacturers.

The next key category refers to navigation system. Some of key features are similar, maps can be download for offline usage or can provide accurate updates about road traffic conditions and also turn by turn directions for driving, public transit or walking routes. The only difference is that Google Maps do have cycling directions and Apple maps do not. In total, Google Maps have more detailed interesting points and incomparable in terms of quality and scale. As far as updates are concerned, Apple's iOS has regular software updates and security patches. Approximately 80% of iOS devices contain the latest version iOS 12, iOS 11 only 17% and the rest 5 %. Unlike Android devices that are running on the latest Android 9 Pie, have much smaller percentage of smartphones with comparison to iOS. [41]

Battery life comparison is considered to be one of the most comparable matters in smartphone industry between iOS and Android devices. Each of them has in common information about battery usage or power saving modes for extending the battery life. Until the 2017, Android was leader, because their phones supported wireless charging. However, iPhone decided to change these statistics, after releasing the iPhone 8.

iPhone models, starting with iPhone 8 up to the latest iPhone version began to support wireless and fast-charging. The only difference is with fast-charging adapter. When ordering an android phone, fast charging adapter is provided in the box. In the second case, fast-charging adapter has to be bought separately, when buying iOS device. [41]

Both operating systems contain Voice assistant. Apple has Voice assistant called Siri and Android has Google Assistant. Siri is useful in terms of setting an appointment, searching some information on the internet or for making calls. However, Google Assistant has an extra ability, including beneficial suggestions, may offer an entertaining games or information, which follows from a current activity. Google Assistant is more preferred, because of universality and smartness. Siri was marked by new capability in the latest iOS 12, which uses voice commands to launch groups of automated tasks. Voice assistants for both operating systems are improving and getting to more functional state. [41]

Unlike iOS, Android is leader in the field of free applications that makes this operating system more affordable. Despite the fact that Google Play Store has more free applications than Apple's App Store, iOS is more profitable for developers. There is a possibility that the best mobile games arrive to iOS first and never will be available on Android.

In terms of photo and video backup, Android provides Google photos with possibility of 15GB storage for with Google Drive (now Google One). Advantage of purchasing a Google Pixel, there is a possibility of backing up the unlimited photos and videos in full resolution. Despite the fact that on iOS platform, iCloud allows only 5 GB of storage. However, Google Photos can be also applied on iOS. In order to get additional space, Google One has 100 GB for only 2\$ per month and 2 TB for 10\$. The highest possible storage for Google One is 300\$. For iCloud, the price is only 1\$ per month 50GB and 2TB for 10\$. [41]

Another reason why customers often prefer Android to iOS is customization. Android allows to set up the many things such as home screen or any different SMS application can be installed. The possibility of modifying the home screen by getting new launchers, widgets or icons. Android also allows access to many third-party applications or in other words, the applications, which were not made by the device maker. This is the main iOS issue, because many Android supported applications are not supported by iOS.

Security is also considered to be very important aspect. The malware threats are getting more serious and many Android devices are running on years old software versions. On the grounds of this disadvantage, these devices can be vulnerable to dangerous hacks such as Stagefright or Heartbleed. In the second case, Apple has worked out on security by

launching Touch ID, Face ID, which could be seen first on iPhone X and since then on the latest iPhones. There is no possibility of risk, because Apple prefers encryption of all personal data, which is not stored and provides security with privacy. On the contrary, Android provides less privacy, because only some of the data is encrypted. Google creates an advertisement based on provided information and Google also stores the location of user, everytime when phone is turned on. In terms of security, Apple is convinced that Google provides false assurance. Moreover, Apple had a dispute with FBI. Apple turned to courts of United States with an intention to force the manufacturers to help with unlocking the mobile phones, which data are protected by encryption. [41]

Rooting and Jailbreaking are common processes featuring on iOS and Android devices. Rooting is a procedure running on Android which allows complete access to the device and to dig further into the system. Rooting provides possibility to get into the entire operating system, access to more applications, settings, features[41].

Rooting offers benefits such as ability to get rid of pre-installed unwanted applications or modifications, which help to speed up device or extend battery life called custom ROMs[42].

However, rooting may cause a several difficulties to the Android phone devices. After the rooting procedure is finished, most of the phone manufacturers invalidate warranty. Some issue may occur during the procedure. This term is called bricking of phone, which can be defined as the device, which is useless and will not be able to function normally. This is the combination of bricked phone without ability to be repaired under warranty. The reason of rooting a device is to increase the performance, but however this attempt may result in losing a performance and features or probability of getting the viruses,[42].

On the other hand, Jailbreaking is an iOS possibility. Jailbreaking is a process, which allows user to download applications from the other sources than Apple Store and somehow get around restrictions applied by manufacturer. Jailbreak also enable to change default browser of iPhone or email client, moreover to use software, which is forbidden by Apple. [43]

There is no limitation to use the App Store or iTunes even after the jailbreaking, because the access for device will not be affected. The first thing before the beginning of jailbreaking is to back up an important data. The other step after the beginning is to update the iOS to its latest version.[44]

However, before the process, user needs to consider its benefits and drawbacks. One of the biggest benefits is already mentioned possibility of getting new unofficial applications and ability to remove pre-installed applications. The next feature is free tethering. By jailbreaking, devices get free hotspot feature due to MyWi application. [45].

The reason why users use the option of jailbreaking is useful customizability. By using Cydia, which is unofficial alternative to an App Store, there is wide range of options for better customization of device such as changing of wallpaper, icons. After getting around the limitations, users can benefit to reach access to the iOS file systems. With installation of secure shell client, users are capable of transferring the data between two devices in a network. Secure shell client can be used for connection of iPhone to computer and fix damaged files in mobile.[46]

Jailbreaking also offers other untypical services including the change of wireless provider, the only thing to do is to change SIM card. Moreover, the jailbreaking process works due to jailbreakme application, which can be opened through the browser. The process itself is very simple and is not time demanding for the successful execution. The another-mentioned possibility of all is full reversibility. After the fear from potential failure, user may change his mind. The only thing to do is to connect iPhone to computer and apply Restore feature in iPhone.

However, jailbreaking has also negative side. As a result of new applications that were not screened, there is a high probability of getting malware into the device or being hacked. As previously mentioned, difficulties with Android also the process of jailbreaking may cause complete void of warranty, moreover bricking the phone, which makes it useless. No possible software updates are available after bypassing the limitations. Jailbreaking can also affect the battery life and the performance of iPhone.[45] [46]

4.2 Samsung Galaxy S10/S10+ vs. iPhone XS/XS Max

Samsung and Apple are considered to be the best and the most well-known smartphone manufacturers. Samsung Galaxy S10 and S10+ are alongside with iPhone XS and XS Max the most powerful and dominant smartphones. Due to these factors, following last subchapter will deal with the comparison of these flagships. As previously mentioned, Samsung Galaxy S10 and S10+ contain the latest processor Snapdragon 855. Apple A12 Bionic is a processor of iPhone XS and XS Max.

According to the most popular processor benchmarks platforms Antutu and Geekbench 4.3 version, it is hard to tell surely whether Apple Bionic A12 or Snapdragon 855 processor is faster.

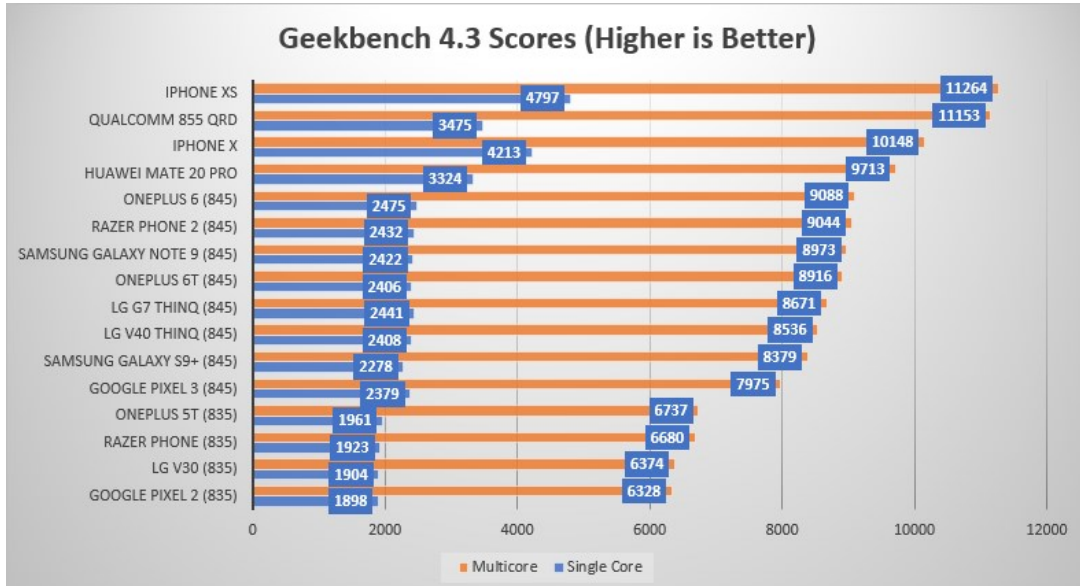


Figure 4. Geekbench 4.3. Retrieved May 12, 2019 from

<https://www.pcmag.com/news/365953/we-benchmarked-the-new-qualcomm-snapdragon-855>

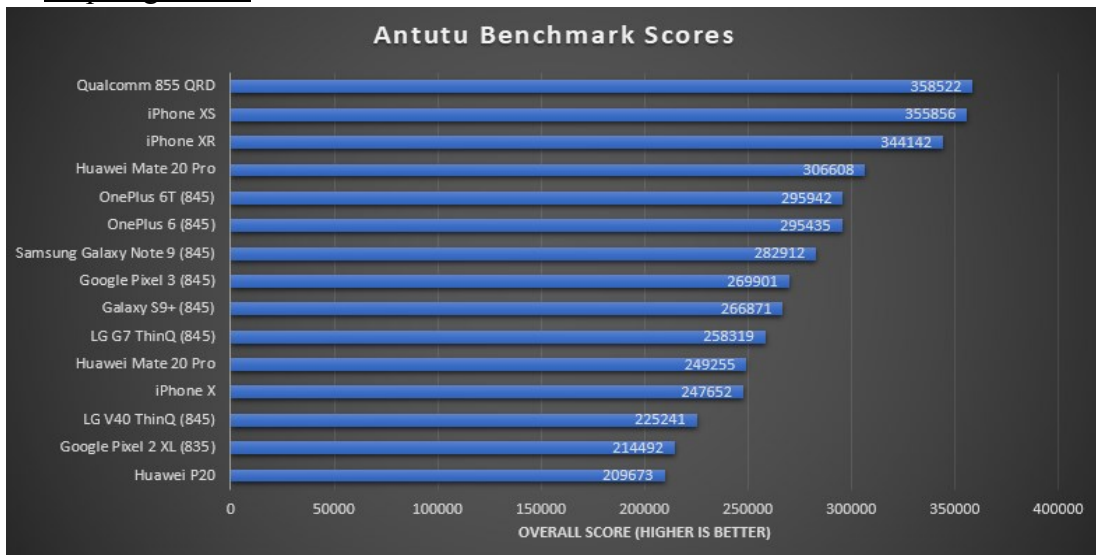


Figure 5. Antutu Benchmark. Retrieved May 12, 2019 from

<https://www.pcmag.com/news/365953/we-benchmarked-the-new-qualcomm-snapdragon-855>

The results of these two initial benchmark tests taken in December have produced very

tight results. For Geekbench 4.3 result, A12 had score about 11264 and Snapdragon 855 obtained score 11153. However, it was different in Antutu benchmark, where Snapdragon 855 won with score 358 522 against A12 with 355 856.[47]

Huawei Mate 20 Pro finished in both tests at fourth place with powerful Kirin 980 processor. This is the example, which shows the power of Snapdragon 855 and Bionic 12. These results will not have the same number everytime after the benchmark tests are carried out. However, it does not change the fact that with the contribution of negligible deviations, the results of these two smartphone processors will still prove their dominance on the market. After the certain period of time, the new upcoming Snapdragon 865 and Apple's Bionic A13 will show even more dominance and mutual competition.

Another attribute Samsung and Apple have in common is wireless charging, but Samsung can provide tricky feature called Wireless PowerShare, which means that Galaxy smartphones can charge each other by touching the back sides of the phones. Samsung Galaxy S10 and S10+ have larger batteries (3500 mAh and 4100 mAh) with comparison to iPhone XS and XS Max (2659 mAh and 3174 mAh).[48]

However, several ways were tried with aim to test and compare the battery life and the results were not so different and definite. One of the many examples included the test between the smartphones with better batteries, Samsung Galaxy S10+ and iPhone XS Max. The test was comprised of phone call for about 60 minutes, which resulted in iPhone dropping less than Samsung's battery. Following one hour messaging test equalised the state of phone batteries. Subsequently, during e-mails reading test, Samsung proved the dominance and took the lead until the end. It was followed by pages scrolling on the browser, standby test, watching Youtube videos, playing games and the others. After both having several hours of standby test, Samsung managed to have screen on and perform the already mentioned functions for 9 hours and iPhone only for 1 hour less.

Samsung is also ahead referring to cameras. These two iPhones feature 12MP dual rear cameras, one wide-lens camera and one telephoto zoom camera. However, Samsung has the same 12 MP dual rear cameras, but also 16 MP ultra wide camera. Both, iPhone XS and XS Max have single 7 MP front camera, Samsung Galaxy S 10 has also single front camera, but feature 10MP dual pixel sensor. Galaxy S10+ has a dual front camera and with 10 MP dual pixel camera, it contains addition of 8MP RGB depth sensor. [48]

At first glance it is interesting to see that iPhone XS is the smallest with 5,8-inch display

and is followed by Samsung smartphones, Samsung Galaxy S10 with 6,1-inch display and S10+ with 6,4-inch display. The second version iPhone XS Max leads with 6,5-inch display.

It is important to tell about information referring to 5G connectivity and the fact that Samsung Galaxy S10, S10+ and iPhone XS, XS Max does not feature this technology. However, Samsung came up with an idea to develop another model called Samsung Galaxy 10 5G. This model is the largest with comparison to that four models. Samsung Galaxy 10 5G features Exynos 9820 processor, which is also another global possibility for Galaxy S 10 series used outside the USA. Except for this processor, S10 5G version features large 6,7-inch display, 4500mAh battery, quad rear cameras containing dual 12MP wide and telephoto camera, 16MP ultra wide camera, moreover also time-of-flight camera, front camera consists of 10 MP dual pixel camera.

CONCLUSION

Smartphones have created a new possibility of communication between people, after introducing these devices into a reality. Smartphones enabled people to communicate in any place without being dependent on any particular place. The first chapter provided description of history, evolution of smartphones and the introduction of mobile communications. When text messages became popular, people were able to send basic information discretely, without the need to use the spoken word.

In the short period of time, communication had been extended by the use of multi media messages. Mobile devices used the ability to create photos and to send image files. By increasing the level of technology in mobile phones, recording of static image was enhanced by the sending of dynamic image in the form of videos.

At present, smartphones are enabled to work in an environment of a high-speed internet, which is largely focused on the use of social networks. People can communicate with each other by means of these networks and gain valuable information. Moreover, modern smartphone technologies have ability to communicate with car and using applications, smartphone is even able to control lighting or heating of buildings.

Nowadays, smartphones contain improved components and innovations, which offer many other conveniences. The second chapter described in details the latest trends and future innovations of smartphones. Whether it is better display or better cameras, more enhanced hardware components along with more useful software applications. Every new type of processor, larger display, battery that lasts longer than a previous one, all of these and the others innovations create new unforgettable experience.

The third chapter provides the view into the world of smartphone market share. The aim was to clarify the market share more closely and compare the shipment volume of the most significant smartphone brands with the previous year. Business is very important for smartphone companies, because every brand wants to improve and enhance their position on the global market.

The last chapter dealt with the comparison of parameters of Apple and Samsung. In my opinion, it was necessary to point out the best smartphones from both brands and compare them from the different points of view. After the completion of the last chapter, conclusion of the bachelor's thesis follows.

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